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I. Fundamental Deformation Characteristics of 80 Nickel - 20 Chromium  
Alloy in Creep at Elevated Temperatures

II. Aging in Nickel - Chromium Alloys Hardened with Titanium and Aluminum

PERIODIC STATUS REPORT NO. 2

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DEPARTMENT OF METALLURGY  
CAMBRIDGE, MASSACHUSETTS

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## I. Fundamental Deformation Characteristics of 80 Nickel - 20 Chromium Alloy

### in Creep at Elevated Temperatures

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Since the last quarterly report (October 1952) several preliminary creep tests were run at 1150° F. Some interesting results were obtained, particularly regarding the behavior of slip bands in crossing twin boundaries.

#### Preparation of Specimens

Two parallel flat surfaces were milled in the gage portion of the test bars. The specimens were first stress relieved at 900° F for 20 hours. They were then stretched 4 percent at room temperature and given a final anneal at 2350° F for 24 hours. The grain size after this treatment ranged from 0.2 to 1.5 mm in diameter. In common with certain other austenitic structures, annealing twins were found in the grains. The specimens were electro-polished in a mixture of methyl alcohol (two parts) and nitric acid (one part). Because etching darkened the appearance of the specimen surface, the specimen was tested in creep without prior etching. It will be seen later that the grain and twin boundaries could be established after small amounts of deformation without etching.

#### Results

Specimen N-1 was subjected to creep at 1150° F. Immediately after loading (stress about 20,000 psi), this specimen was elongated 4.2 percent. Because some interesting deformation patterns were observable microscopically during the creep test, the test was stopped and the specimen was taken out of the furnace for examination.

There were two types of deformation patterns noted in the twins which were caused by slip in the grains.

As shown in the upper portion of the large grain at the right side in Figure 1, the twins are fairly wide. The slip bands are sharply bent and continuous in going across the twin boundaries. The slip bands appear regular and straight in the twins.

The second type of deformation in the twins is shown in the lower portion of the larger grain at the right side of Figure 1. The twins narrowed down in going from the top to the bottom of the same grain. It is interesting to note that the heavy slip bands in the grain disappear almost suddenly at the twin boundaries. The heavy slip bands at both sides of the twin are connected

by faint markings in the twins. Figure 2 shows at higher magnification the lower portion of this grain. In fact, the faint marks in the twins are slip bands having a zigzag pattern.

Figure 3 shows a case where two heavy parallel slip bands can also be connected by these zigzag slip bands in going through the twin (or bundles of twins).

#### Future Work

It is planned to study in some detail the conditions of the occurrence of these two types of deformation patterns in the twins. It is thought that the following factors are important for their occurrence.

1. The width of the twins relative to the magnitude of the applied stress.
2. The arrangement of the twins and the grain with respect to the neighboring grains; i.e., the orientation effect and the depth of the twin (in the direction of the thickness of the specimen).

It was found that the specimen surfaces could not be maintained clean even for only several hours at 1100° F. The gas - tightness of the creep furnace was checked and improved accordingly. With the present set up, creep tests can be run up to 1600° F. Three specimens are ready for such creep tests.

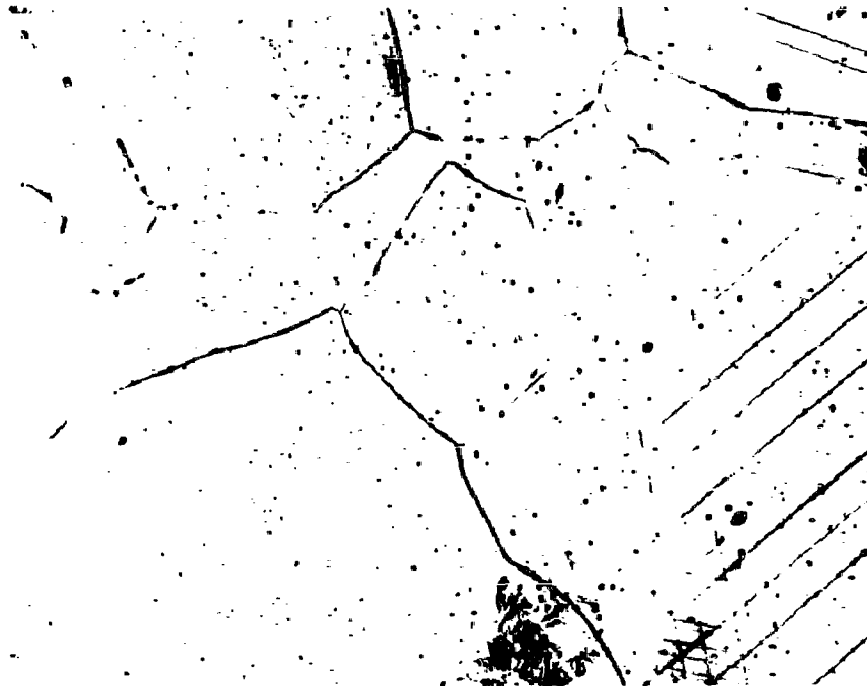


Figure 1. Specimen N-1, 1150°F, 20,000 psi. The behavior of slip bands across twins. The slip bands are sharply bent and continuous at the twin boundaries, as shown in the upper portion of the large grain at the right. The heavy slip bands are connected by faint markings in the twins as shown in the lower portion of the same grain. 150X.



Figure 2. Specimen N-1, 1150°F, 20,000 psi. A higher magnification of the lower portion of the large grain described in Figure 1. The faint markings in Figure 1 are actually regular slip bands in zigzag pattern. 500X.

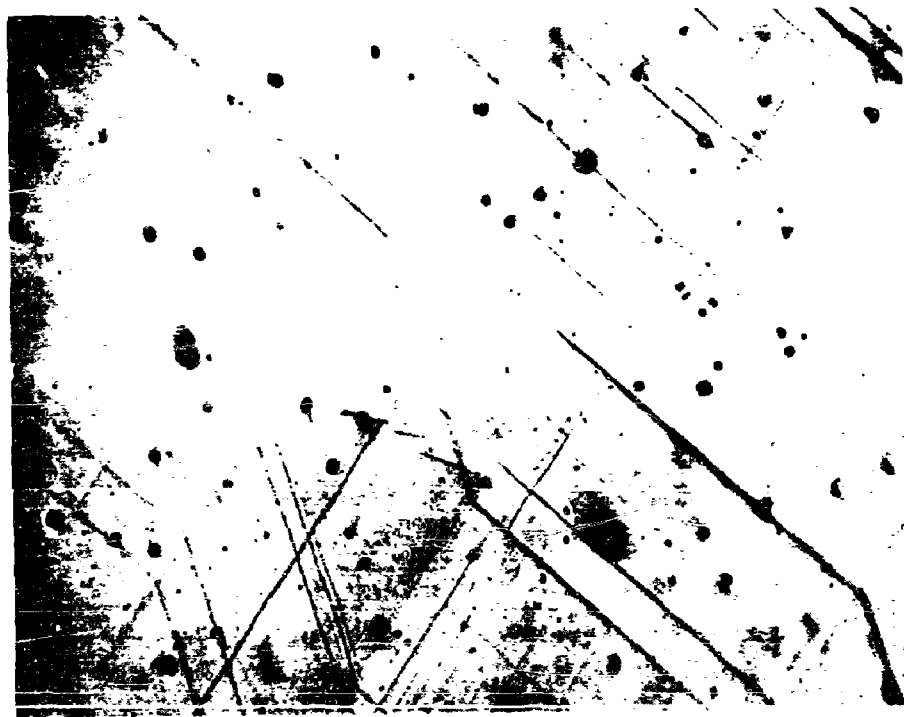


Figure 3. Specimen N-1, 1150°F, 20,000 psi. Two parallel slip bands are connected by regular slip steps in zigzag pattern. 500X.



Resistivity and hardness measurements affixed the different nature of these two types of precipitate.

Since the preparation of the first report creep and stress rupture tests have been started. So far these have been conducted at 1,500° F only. The results of these tests indicate that the alloys hardened with the first type of precipitate, behave in the same general manner irrespective of the relative amounts of aluminum and titanium. It looks, however, as if the alloys with a high titanium to aluminum ratio have a longer rupture life and a substantially lower minimum creep rate. Alloys hardened with the acicular type of precipitate showed inferior high temperature properties, especially a higher creep rate.

These tests will be continued and attempts will be made to extract the precipitated constituents.

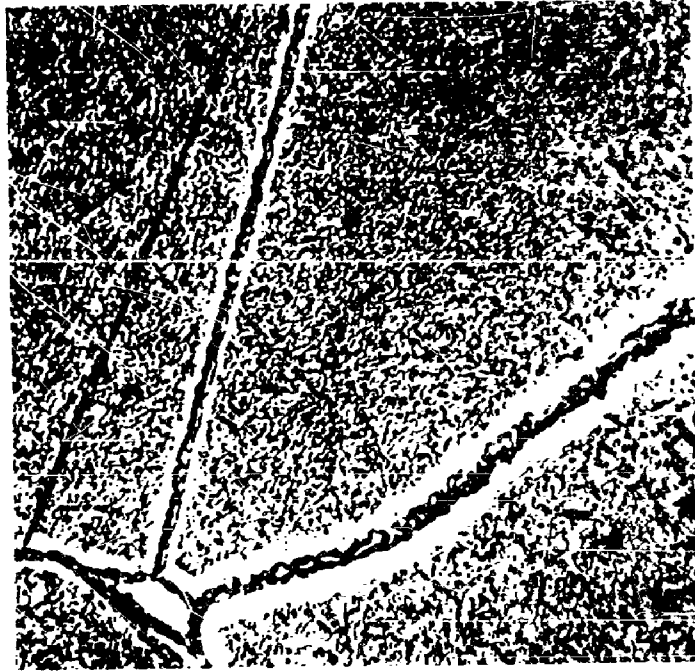


Figure 1. 2.2 percent titanium and 0.9 percent aluminum (by weight), water quenched from 2000° F and aged 540 hours at 1450° F. Etched electrolytically in aqueous solution of 10 percent glycerine and 5 percent hydrofluoric acid. 1500 X.

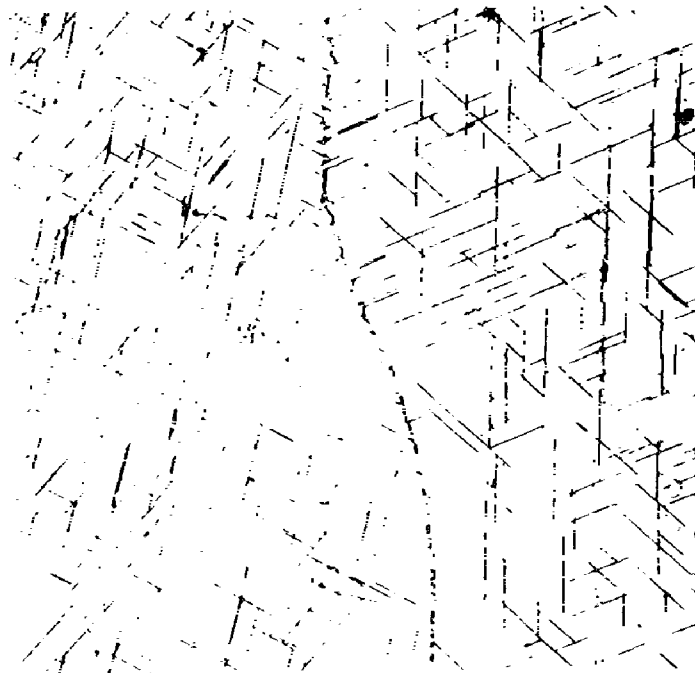


Figure 2. 3.7 percent titanium (by weight), water quenched from 2000° F and aged 90 hours at 1650° F. Etched electrolytically in aqueous solution of 10 percent glycerine and 5 percent hydrofluoric acid. 500 X.